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(72) ALBINSKI, Christian, DE
(71) Continental Aktiengesellschaft, DE

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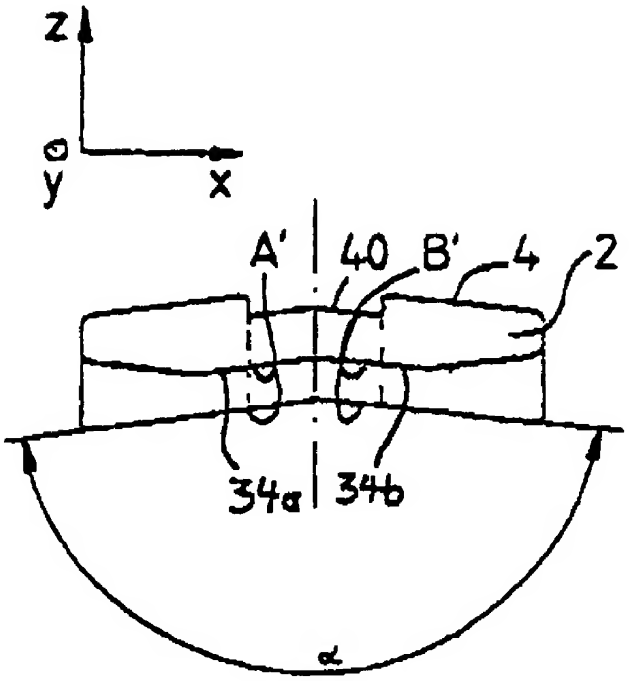
(54) **BOITIER DE PROTECTION POUR UNE COMPOSANTE ELECTRONIQUE**

(54) **PROTECTIVE HOUSING FOR AN ELECTRONIC COMPONENT**



(57) TRANSLATION NOT AVAILABLE AT THIS TIME

(57) Protective housing for an electronic component to be integrated into a drop base of a vehicle rim. The vehicle rim may include a drop base bottom and an inner and outer drop base flank. The protective housing may include a bottom portion having first and second faces to be oriented toward the drop base. The first and second faces may be formed to be tightly nestled against the vehicle rim.

ABSTRACT OF THE INVENTION

Protective housing for an electronic component to be integrated into a drop base of a vehicle rim. The vehicle rim may include a drop base bottom and an inner and outer drop base flank. The protective housing may include a bottom portion having first and second faces to be oriented toward the drop base. The first and second faces may be formed to be tightly nestled against the vehicle rim.

FIG. 1a

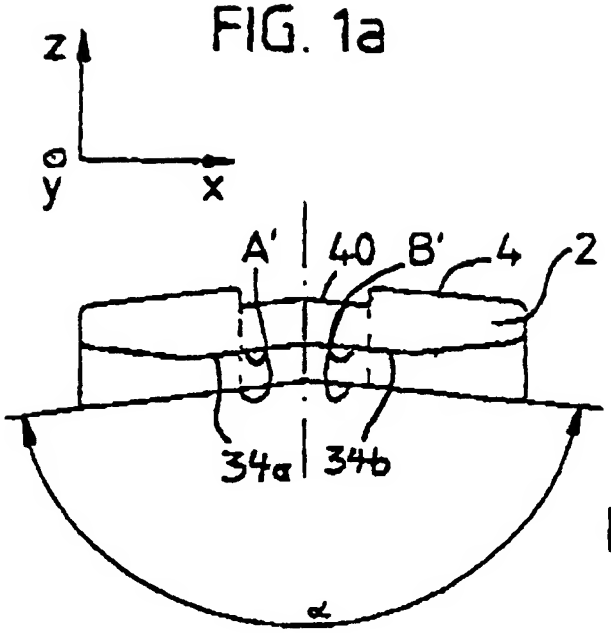
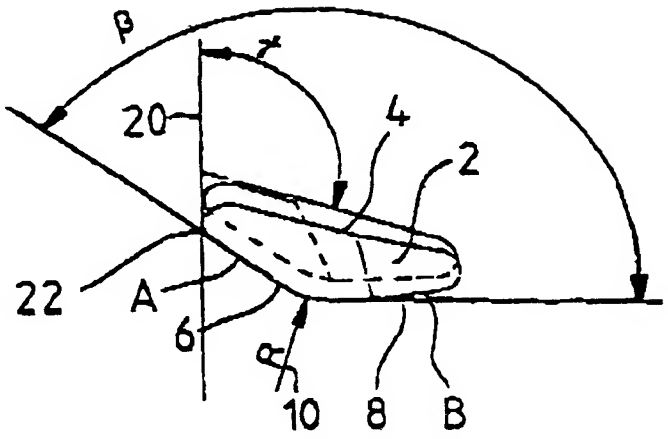


FIG. 1b



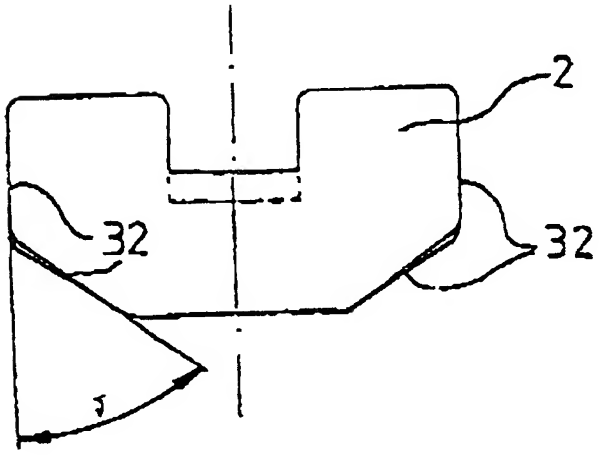


FIG. 1c

Schematic Illustration (points 2 & 4 substantially rest on surfaces 16 & 18)

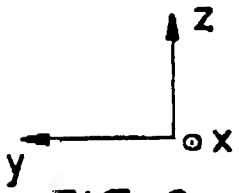


FIG. 2a

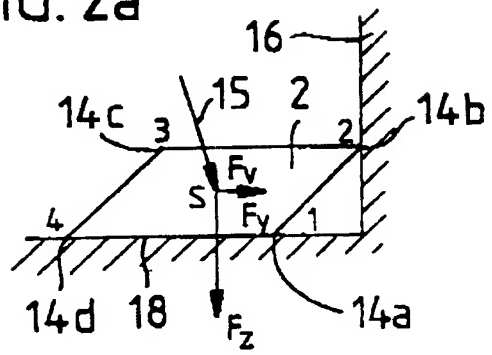
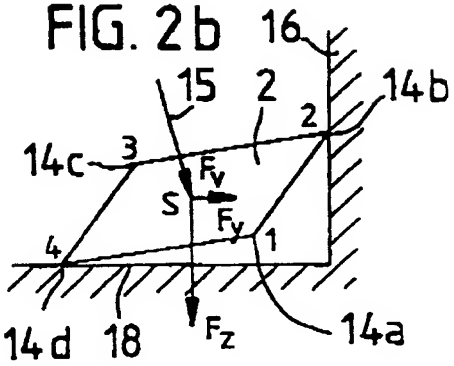


FIG. 2b



(depicted with altered geometry)

FIG. 2c

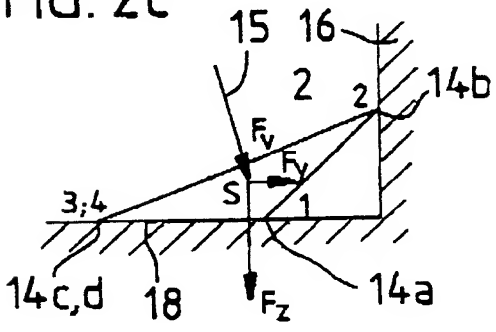
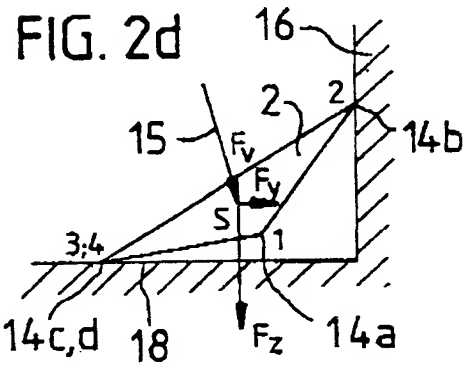
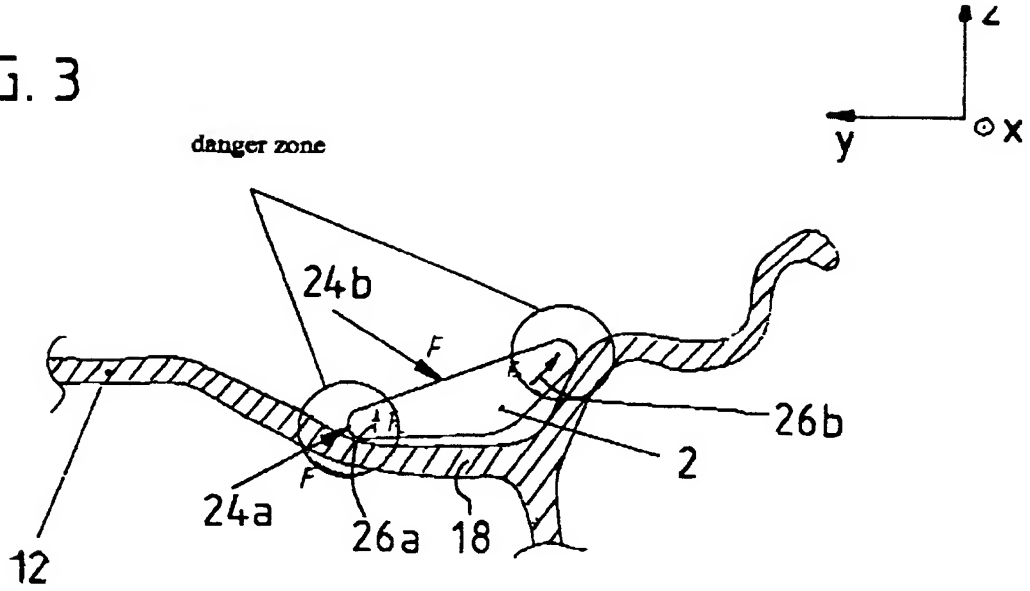


FIG. 2d



F_V = force of the initial tension (e.g. produced by a spring element)

FIG. 3

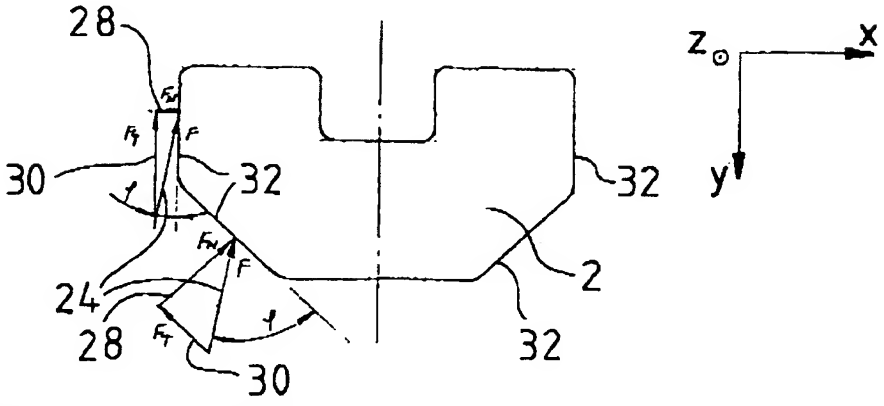


F = force acting from the outside

F_1 = module "drifts" out from the drop base of the rim

F_2 = module lifts up from the drop base contour

FIG. 4

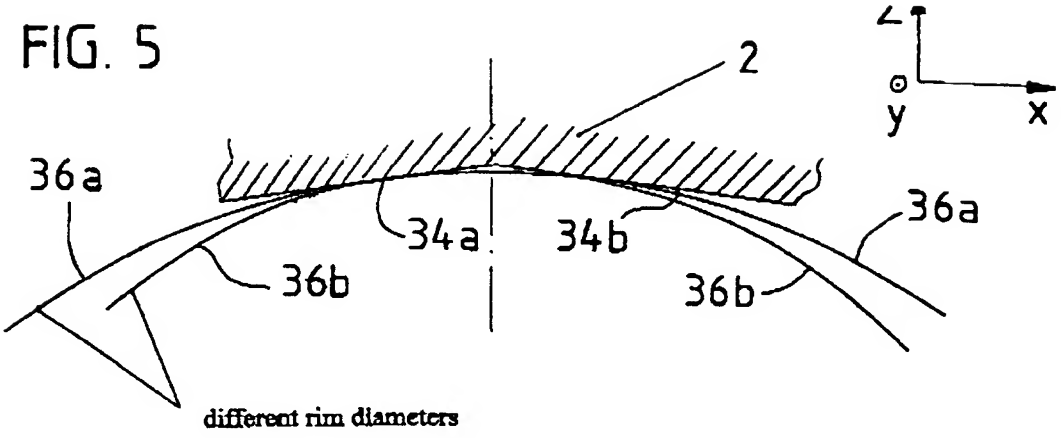


F = force acting from the outside

F_N = normal force

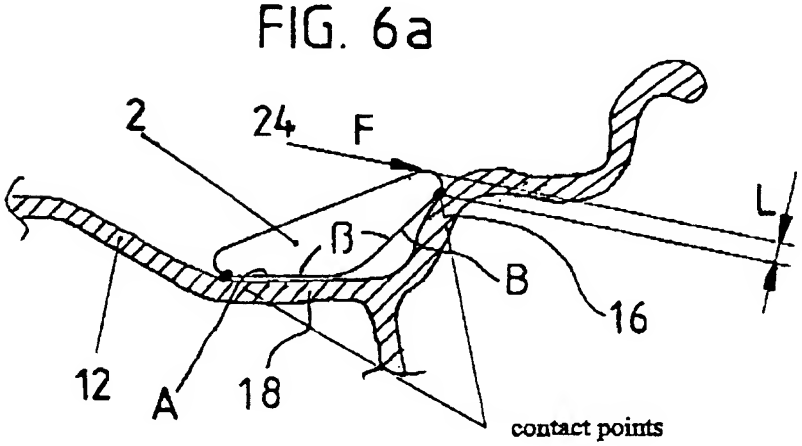
F_T = tangential force

FIG. 5

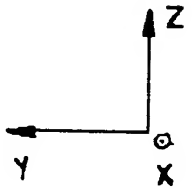


different rim diameters

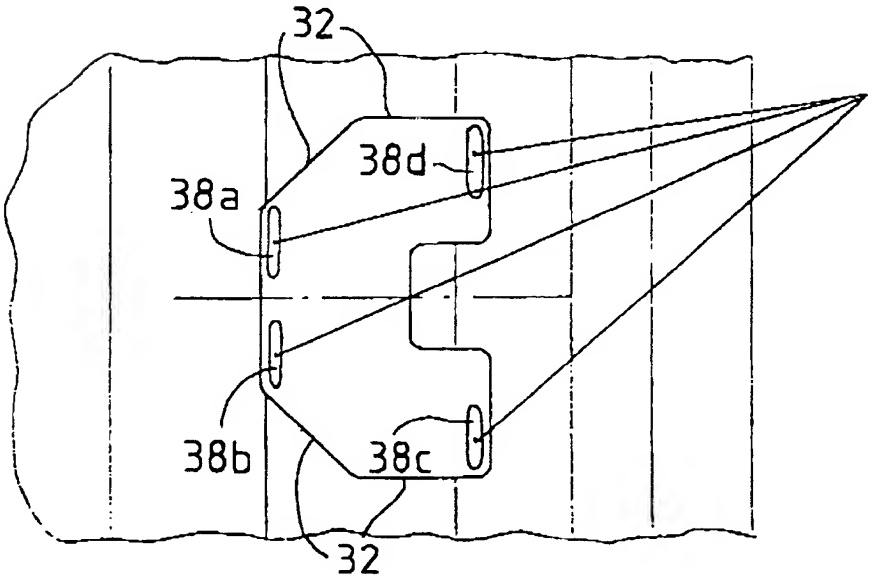
FIG. 6a



contact points



$M = F \cdot L$



Preferred regions in which the module should come into contact

FIG. 6b

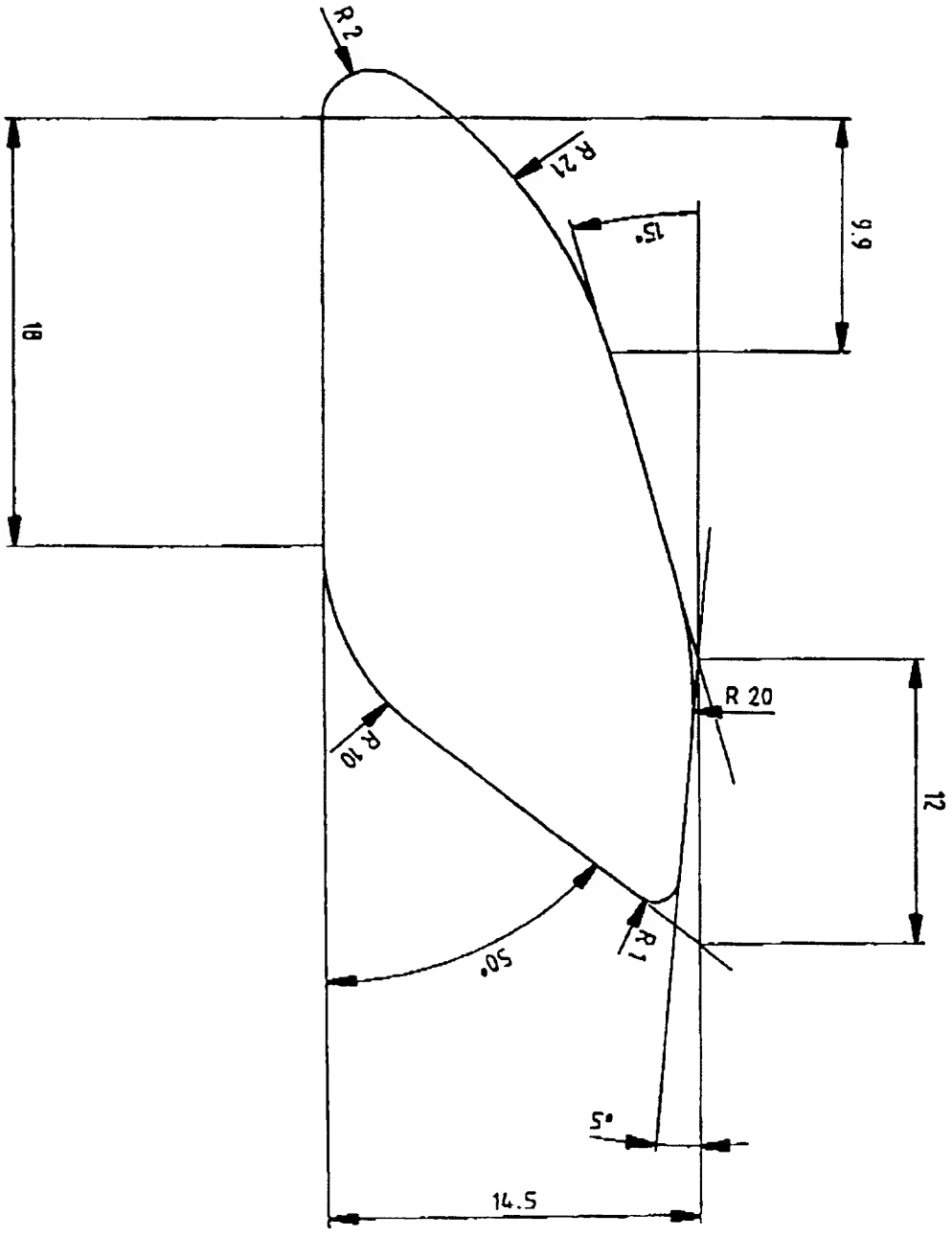


FIG. 7

PROTECTIVE HOUSING FOR AN ELECTRONIC COMPONENT

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority from German Patent Application No. 196 26 144.9 filed on July 1, 1996, the disclosure of which is expressly incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Summary of the Invention

The present invention relates to a protective housing for an electronic component that may be integrated into a drop base of a vehicle rim.

SUMMARY OF THE INVENTION

The present invention includes optimally integrating an electronic component of a predetermined type, e.g., an electronic module, into a drop base of a vehicle rim so that the integration is optimized in every respect. Accordingly, a protective housing may be formed to be as flat as possible, i.e., to include a low center of gravity, and nevertheless, may include a sufficiently large volume for accommodating the electronics and a battery.

The present invention provides the optimal integration of the electronic component in that outermost faces or surfaces defining the protective housing of the electronic component in a y-coordinate direction, i.e., laterally with respect to a circumference of the vehicle rim, may be brought into contact with a drop base flank and/or a bottom of the drop base of the vehicle rim. The protective housing may include two rear faces that may form an angle β which is to be greater than an angle between the flank and the bottom of the drop base. Alternatively, in lieu of the bottom of the drop base, a second drop base flank may be utilized as a support. Because of this particular geometric arrangement of the outer contour of the rear faces of the electronic component housing and because the housing of the component or module may rest on the bottom of the drop base while a space between the module housing and the flanks of the drop base is simultaneously minimized, a tire lever, pressure blade, or the like may be prevented from hooking under the module housing. Further, a housing geometry may be established such that the module housing may be utilized within

substantially all rim types without limitation or hinderance of function.

A specified angle β and a selection of lengths for legs A and B, i.e., the two bottom faces of the module housing, that form the specified angle β may be chosen so that contact points located on a side of the drop base flank may be located as high as possible in a z-coordinate direction, i.e., radially with respect to the vehicle rim. This arrangement may reduce the potential danger of the module being lifted up from the drop base contour due to moments acting around the contact points and produced by external forces.

Since the module is intended to fit within the drop bases of various vehicle rims, a minimum radius R, which couples legs A and B in forming angle β, and a minimum angle β may be determined by minimal and maximal values established by the European Tire and Rim Technical Organization (ETRTO) for drop bases of various vehicle rims. Radius R may be, e.g., greater than or equal to approximately 10 mm.

Further, each bottom face of the module may include two or more faces inclined toward one another, i.e., at an angle α less than approximately 180° to form legs A′ and B′. In accordance with this arrangement, the module may be adapted to be positionable and utilized with various different rim diameters.

A top of the module housing may form an angle γ between a highest position, in the z-direction, of part faces, i.e., external surfaces, of the module top and a line, in the z-direction, tangent to an outermost point of the module on the drop base flank side, which is always greater than or equal to approximately 90° and less than or equal to approximately 180°, i.e., approximately $90° \leq \gamma \leq 180°$. This configuration results in minimizing the force components of the force acting on the module from the outside, which could potentially cause the module to drift out of the drop base or to lift up from the drop base contour. Consequently, the potential danger of damage to the electronic module may be reduced to a large extent.

Another alternative embodiment may provide a majority of the external surfaces that laterally define the module in the x-direction may be inclined at an angle δ so that a force substantially exerted within the x-y plane and acting on the electronic module from the outside constitutes as

sharp, i.e.., small, an angle ϕ as possible with respect to the faces. Preferably, the angle δ is selected such that δ is greater than or equal to approximately -45° and less than or equal to approximately 45°. As a result of this arrangement, the normal force component of the force directed from the x-y plane may assume a minimum.

Remaining laterally-acting forces in the circumferential (or x-direction) or forces that would cause the module to drift out of or away from the drop base or to lift up from the drop base contour may be absorbed by a module fastening system. In this regard, the fastening system of the protective housing may be designed so that the module is not damaged when overloaded and so that the density of the finished wheel remains preserved.

By and large, the housing according to the present invention may permit an electronic component to be optimally integrated into the drop base of motor vehicle rims. The geometrical configuration of the outer contour may reduce the potential for damaging the module from external forces or for lifting the module out of the drop base.

The present invention may therefore be directed to a protective housing for an electronic component to be integrated into a drop base of a vehicle rim. The vehicle rim may include a drop base bottom and an inner and outer drop base flank. The protective housing may include a bottom portion having first and second faces to be oriented toward the drop base. The first and second faces may be formed to be tightly nestled against the vehicle rim.

According to another feature of the present invention, the first and second faces may define first and second contact legs of the protective housing in a y-direction, so that the first and second contact legs adapted to be coupled to the flank and the drop base bottom, respectively. The first and second contact legs may form an angle β, in which β is less than or equal to approximately 180° and greater than or equal to approximately 90°, and the flank and the drop base bottom may form an angle less than β. Further, the angle β and lengths of the contact legs may be selected so that the first leg contacts the flank as high as possible along the length of the first leg in a z-direction. Still further, the first and second legs may be coupled through a curved portion having a radius. The radius and the angle β may be determined from minimum and maximum values for drop base rims

indicated by the European Tire and Rim Technical Organization.

According to still another feature of the present invention, each of the first and second faces may include two or more positioning legs forming an angle α in which α is less than approximately 180°.

According to a further feature of the present invention, the protective housing may include a module top arranged such that an uppermost portion of the module top and a line formed parallel to a radius of the wheel rim and including an outermost point of the first face form an angle γ. Angle γ may be greater than or equal to approximately 90° and less than or equal to approximately 180°, i.e., approximately $90° \leq \gamma \leq 180°$.

According to another feature of the present invention, the protective housing may include a plurality of external surfaces laterally defining the protective housing and a maximum of the plurality of part faces may be inclined at an angle δ that is greater than or equal to approximately -45° and less than or equal to approximately 45°. Further, the angle δ may be selected so that an external force mainly acting on the plurality of external surfaces may form as small an angle ϕ as possible.

According to still another feature of the present invention, the protective housing may include a recess formed on a top surface for receiving a fastening bracket.

The present invention may also be directed to a protective housing for electronic components to be mounted on a wheel rim, the wheel rim having a drop base flank and a drop base bottom for receiving the protective housing and forming a rim angle. The housing may include a substantially triangular housing including a top surface and a first and second bottom surface. The first and second bottom surfaces may form an angle β greater than the rim angle and each of the first and second surfaces may include a first and second leg adapted to be seated on the flank and bottom of the drop base.

According to still another feature of the present invention, the first and second leg may contact at least one of the flank and the bottom of the drop base.

According to a further feature of the present invention, the top surface may include a front

face having a plurality of external surfaces. The protective housing may further include side surfaces substantially parallel to an axis of symmetry extending through the protective housing and bisecting the front face, and at least two of the plurality of external surfaces arranged at an angle δ with respect to the side surfaces such that δ is greater than or equal to approximately -45° and less than or equal to approximately 45°.

According to still another feature of the present invention, the top surface may include a peak extending substantially along an axis of symmetry extending through the protective housing and bisecting the first and second bottom surfaces. The peak may form an angle γ with a line extending through an outermost point of the first bottom surface and substantially perpendicular to a line extending from the second bottom surface such that γ is greater than or equal to approximately 90 and less than or equal to approximately 180°.

According to another feature of the present invention, the top surface may include a rear face having a notched portion for receiving a mounting element.

According to a still further feature, the angle β may be formed with a curved portion having a radius of curvature. Further, the radius of curvature may be approximately 10 mm.

The present invention may also be directed to a protective housing for enclosing electronic components in combination with a wheel rim. The wheel rim may include a drop base flank and a drop base bottom receiving the protective housing and forming a rim angle. The combination may include the protective housing having a first and second bottom face forming an angle therebetween greater than the rim angle. A portion of the first bottom face may be coupled to the drop base flank and a portion of the second bottom face may be coupled to the drop base bottom.

According to another feature of the present invention, the first bottom face may include a first and second leg and the second bottom face may include a third and fourth leg. The first and second leg may form an angle to seat the first bottom face on the drop base flank and the third and fourth leg may form an angle to seat the second bottom face on the drop base bottom.

According to a still further feature of the present invention, the protective housing may also include a top surface including a peak extending substantially along an axis of symmetry extending

through the protective housing and bisecting the first and second bottom faces. The peak forming an angle γ with a radial line extending from the wheel rim through an outermost point of the first bottom surface such that γ is greater than or equal to 90° and less than or equal to 180°.

According to still another feature of the present invention, the first bottom surface may include a contacting portion remote from angle β and the drop base flank may be coupled to the first bottom face at the contacting portion.

According to yet another feature of the present invention, the protective housing may also include a top surface having a front face with a plurality of external surfaces. The protective housing may also include side surfaces substantially perpendicular to a tangent of the wheel rim and substantially parallel to an axis of symmetry extending through the protective housing and bisecting the front face. At least two of the plurality of external surfaces are arranged at an angle δ with respect to the side surfaces such that δ is greater than or equal to approximately -45° and less than or equal to approximately 45°. Further, the plurality of external surfaces may be arranged to minimize the effects of external forces acting on the protective housing.

Other exemplary embodiments and advantages of the present invention may be ascertained by reviewing the present disclosure and the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be further described in the detailed description which follows, in reference to the noted plurality of drawings by way of non-limiting examples of preferred embodiments of the present invention, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

Figures 1a, 1b, and 1c illustrate a front, side, and top view, respectively, of a protective housing in accordance with the present invention;

Figures 2a, 2b, 2c, and 2d schematically illustrate the protective housing and required forces of initial stress;

Figure 3 illustrates a cross section of a protective housing according to the present invention positioned in relation to a wheel rim;

Figure 4 illustrates the action of a force component at an angle ϕ acting on the module from the outside (i.e., with regard to the lateral definition of the module);

Figure 5 illustrates the fit of a bottom portion of the protective housing according to the present invention on different rim diameters (i.e., alternative rim sizes);

Figure 6a and 6b illustrate contact points of the protective housing according to the present invention cross sectionally and in a front view, respectively; and

Figure 7 illustrates s a cross section through an arrangement of the protective housing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The particulars shown herein are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for the fundamental understanding of the invention, the description taken with the drawing figure making apparent to those skilled in the art how the invention may be embodied in practice.

The present invention is described with respect to a three dimensional coordinate system related to a wheel rim to which the protective housing is to be mounted. Specifically, the x-direction is tangential to the wheel rim, the y-direction is transverse to the tangent along the wheel rim surface, and the z-direction extends along a radius of the wheel rim.

As is illustrated in Figure 1b, a cross-sectional view of a protective housing or module 2 may be formed as a three-sided, i.e., substantially triangular, surface including a top surface 4 and faces 6 and 8 positioned on the bottom. Faces 6 and 8 may be arranged to form legs A and B, respectively, and legs A and B may form an angle β. To prevent a hooking from underneath protective housing (or module) 2 when mounting to a wheel rim, angle β should always be greater than an angle formed between a flank 16 and bottom of a drop base 18 in the wheel rim, as illustrated in Figure 6a.

A radial transition (R) 10 may be formed between face 6 and face 8. Since protective housing or module 2 is configured to be utilized with various sized rims 12, in order to ensure that

module 2 will fit into the various drop bases of the wheel rims (see Figure 6a), a minimum radial transition 10 and a minimum angle β may be determined from minimal and maximal values for the specific drop base rim as indicated in the ETRTO (European Tire and Rim Technical Organization). While the angle formed between flank 16 and bottom of drop base 18 (which should be maintained as less than β) may not be explicitly disclosed in the ETRTO, the angle may be derived from other indicated measurements.

As is further illustrated in Figure 1a, top 4 may include a recess 40 for receiving a receiving a fastening bracket (not shown).

Schematic illustrations of the cross sections of protective housing 2 are shown in Figures 2a and 2b or 2c and 2d. In the figures, at least points 14 b and 14d should be substantially in contact with the wheel rim. As a result of outermost possible edges 14b and 14d shown in Figures 2a and 2b, or edges 14b and 14c, d shown in Figure 2c and 2d, module 2, in a y-direction, may be brought into contact with flank 16 and bottom 18 of the drop base, respectively. As shown in Figures 2a - 2d, a force F_v 15 directed toward flank 15 in a y-direction, i.e., F_y, and toward drop base bottom 18 in the z-direction, i.e., F_z, may be provided by the fastening bracket, e.g., a spring element. Force 15 may be utilized to seat module 2 in place on the wheel rim, and this particular contact between module 2 and the wheel rim may prevent the tire lever, pressure blade, or the like from hooking under and damaging protective housing 2.

As further shown in Figure 1b, module top 4 may be configured to form an angle γ between a maximum or highest position of the part faces, i.e., external surfaces, of module top 4, e.g., a central peak portion, and a perpendicular 20 descending through an outermost point 22 of module 2 (i.e., in a y-direction) on a side of module 2 be associated with drop base flank 16. In accordance with the present invention, angle γ may be greater than or equal to approximately 90° and less than or equal to approximately 180° (i.e., approximately $90° \leq \gamma \leq 180°$). Thus, as shown in Figure 3, certain forces may be exerted on module 2 from the outside. For example, force F 24a may be externally exerted on or near the contact point between module 2 and drop base 18 which may result in a lifting force F_2 26a and force F 24b may be externally exerted on the top of module 2 and

directed toward the junction of flank 16 and bottom 18 of the drop base which may result in a drifting or slipping force F_1 26b. However, due to the configuration of module 2 and to the seating of module 2 on the wheel rim, force components 26a and 26b may assume a minimum value.

The external forces F exerted or acting on module 2, i.e., 24a and 24b, may be considered by examining the force components directed substantially in the x-y plane by resolving the force components into a normal force F_N 28 and tangential force F_T 30 with respect to the external surfaces of module 2 being acted upon by external force F. Figure 4 illustrates external force 24 which may act on external surfaces 32 of module 2 as well as its component normal force F_N 28 and its tangential force F_T 30 exerted on external surfaces 32. A majority of the external surfaces 32 that laterally define module 2 in the x-direction may be inclined, or obliquely positioned with respect to a side edge, at an angle δ, as shown in Figure 1c, so that external force 24, i.e., the force component directed substantially in the x-y plane and acting from the outside of module 2 may form as sharp, i.e., small, an angle ϕ as possible with external surfaces 32. As a result of the configuration of external surfaces 32, normal forces F_N 28 from externally exerted forces may assume a minimum.

In the x-direction, i.e., tangential to the drop base of rim 12, each bottom face 6 and 8 may be comprised of two or more legs A′ and B′ which may be inclined toward one another such that legs A′ and B′ form an angle α such that α is less than approximately 180°. Legs A′ and B′ may include faces 34a and 34b, respectively In this manner, legs A′ and B′ may be used fit various sized, i.e., diametered, wheel rims, as shown in Figure 5. Specifically, due to the specific angle α formed between legs A′ and B′, whether the wheel rim diameter is large, e.g., 36a, or small, e.g., 36b, faces 34a and 34b of legs A′ and B′, respectively, of module 2 may be properly seated on the rim.

Figures 6a and 6b illustrate that a choice of angle β and lengths of legs A and B that form angle β provides the contact points 38a and 38b of module 2 that contact drop base bottom 18. Further, contact points 38c and 38d of module 2 on a side of the drop base flank 16 should be located as high as possible (i.e., in the z-direction) to reduce the potential that module 2 will be lifted from drop base contours 16 and 18 due to moments acting around contact points 38c and 38d and produced by external force F 24. In Figure 6a, the contact point on flank 16 is located as high as

possible with respect to module 2 so as to minimize distance L because an external force F 24 directed at the uppermost point of module 2 will result in a moment force M around the contact point such that $M = F \cdot L$.

Figure 7 illustrates a cross-section of a complete "dimensioning" of protective housing 2. In Figure 7, each dimension, i.e., length and radius is approximately indicated in millimeters. For example, radius R 20 indicates a radius of approximately 20 mm and radius R10 indicates a radius of approximately 10mm, etc. However, the dimensions shown in Figure 7 are for the purpose of explanation of a preferred embodiment and the present invention should not be construed as limited to these explicit dimensions.

It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the invention has been described with reference to a preferred embodiment, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the invention in its aspects. Although the invention has been described herein with reference to particular means, materials and embodiments, the invention is not intended to be limited to the particulars disclosed herein; rather, the invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

Reference Numeral List

2 protective housing (module)

4 top of the protective housing

6, 8 faces of the housing bottom

10 radius R between the faces of the housing bottom

12 (vehicle) rim

14a, 14b, 14c, 14d outermost edges of the protective housing

15 force of the initial tension

16 flank of the rim base (outside of the wheel)

18 bottom of the drop base

20 perpendicular

22 outermost point of the protective housing (of the module) in the y-direction on the side of the drop base flank 16

24a, 24b force acting on the protective housing from the outside

26a, 26b resulting force components

28 normal force F_N

30 tangential force F_T

32 side face of the protective housing (of the module) [the part faces that laterally define the module (in the x-direction)]

34a, 34b faces of the housing bottom that are inclined in the x-direction toward each other

36a, 36b different rim diameters

38a, 38b, 38c, 38d preferable contact points (of the protective housing against the rim)

40 recess

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A protective housing for an electronic component to be integrated into a drop base of a vehicle rim , the vehicle rim including a drop base bottom and an inner and outer drop base flank, the protective housing comprising:

a bottom portion having first and second faces to be oriented toward the drop base; and

the first and second faces being formed to be tightly nestled against the vehicle rim.

2. The protective housing according to claim 1, the first and second faces defining first and second contact legs of the protective housing in a y-direction, the first and second contact legs adapted to be coupled to the flank and the drop base bottom, respectively;

the first and second contact legs forming an angle β in which approximately $180° \geq \beta \geq 90°$; and

the flank and the drop base bottom forming an angle less than angle β.

3. The protective housing according to claim 2, the angle β and lengths of the contact legs being selected so that the first leg contacts the flank as high as possible along the length of the first leg in a z-direction.

4. The protective housing according to claim 2, the first and second legs coupled through curved portion having a radius;

wherein the radius and the angle β are determined from minimum and maximum values for drop base rims indicated by the European Tire and Rim Technical Organization.

5. The protective housing according to claim 1, each of the first and second faces comprising two or more positioning legs forming an angle α in which α less than approximately 180°.

6. The protective housing according to claim 1, further comprising a module top arranged such that an uppermost portion of the module top and a line formed parallel to a radius of the wheel rim and including an outermost point of the first face form an angle γ, such that approximately $90° \leq \gamma \leq 180°$.

7. The protective housing according to claim 1, further comprising a plurality of external

surfaces laterally defining the protective housing; and

a maximum of the plurality of part faces being inclined at an angle δ such that approximately $45° \geq \delta \geq -45°$.

8. The protective housing according to claim 7, the angle δ selected so that an external force mainly acting on the plurality of faces forms as small an angle ϕ as possible.

9. The protective housing according to claim 1, further comprising a recess formed on a top surface for receiving a fastening bracket.

10. A protective housing for electronic components to be mounted on a wheel rim, the wheel rim having a drop base flank and a drop base bottom for receiving the protective housing and forming a rim angle, the housing comprising:

a substantially triangular housing including a top surface and a first and second bottom surface;

the first and second bottom surfaces forming an angle β greater than the rim angle; and

each of the first and second surfaces comprising a first and second leg adapted to be seated on the flank and bottom of the drop base.

11. The protective housing according to claim 10, the first and second leg positioned to form an angle α less than approximately 180°.

12. The protective housing according to claim 10, the first and second leg contacting at least one of the flank and the bottom of the drop base.

13. The protective housing according to claim 10, the top surface comprising a front face having a plurality of external surfaces;

the protective housing further comprising side surfaces substantially parallel to an axis of symmetry extending through the protective housing and bisecting the front face; and

at least two of the plurality of external surfaces arranged at an angle δ with respect to the side surfaces such that approximately $-45° \leq \delta \leq 45°$.

14. The protective housing according to claim 10, the top surface comprising a peak extending substantially along an axis of symmetry extending through the protective housing and

bisecting the first and second bottom surfaces;

the peak forming an angle γ with a line extending through an outermost point of the first bottom surface and substantially perpendicular to a line extending from the second bottom surface such that approximately $90° \leq \gamma \leq 180°$.

15. The protective housing according to claim 10, the top surface comprising rear face having a notched portion for receiving a mounting element.

16. The protective housing according to claim 10, the angle β being formed with a curved portion having a radius of curvature.

17. The protective housing according to claim 16, the radius of curvature comprising approximately 10 mm.

18. A protective housing for enclosing electronic components in combination with a wheel rim, the wheel rim including a drop base flank and a drop base bottom receiving the protective housing and forming a rim angle, the combination comprising:

the protective housing including a first and second bottom face, the first and second faces forming an angle therebetween greater than the rim angle;

a portion of the first bottom face being coupled to the drop base flank; and

a portion of the second bottom face being coupled to the drop base bottom.

19. The combination according to claim 18, the first bottom face comprising a first and second leg and the second bottom face comprising a third and fourth leg;

the first and second leg forming an angle to seat the first bottom face on the drop base flank; and

the third and fourth leg forming an angle to seat the second bottom face on the drop base bottom.

20. The combination according to claim 18, the protective housing further comprising top surface including a peak extending substantially along an axis of symmetry extending through the protective housing and bisecting the first and second bottom faces;

the peak forming an angle γ with a radial line extending from the wheel rim through an

outermost point of the first bottom surface such that approximately $90° \leq \gamma \leq 180°$.

21. The combination according to claim 18, the first bottom surface comprising a contacting portion remote from angle β; and

the drop base flank coupled to the first bottom face at the contacting portion.

22. The combination according to claim 18, the protective housing further comprising a top surface including a front face having a plurality of external surfaces;

the protective housing further comprising side surfaces substantially perpendicular to a tangent of the wheel rim and substantially parallel to an axis of symmetry extending through the protective housing and bisecting the front face; and

at least two of the plurality of external surfaces arranged at an angle δ with respect to the side surfaces such that approximately $-45° \leq \delta \leq 45°$.

23. The combination according to claim 22, the plurality of external surfaces arranged to minimize the effects of external forces acting on the protective housing.